

**Intrinsic Channel Properties, Scattering Mechanisms, Quantum Transport Properties in
Transition Metal Dichalcogenides**

by

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DISSERTATION

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This is a dedication.

“The fact that we live at the bottom of a deep gravity well, on the surface of a gas covered planet going around a nuclear fireball 90 million miles away and think this to be normal is obviously some indication of how skewed our perspective tends to be.”

— Douglas Adams, *The Salmon of Doubt: Hitchhiking the Galaxy One Last Time*

ABSTRACT

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Abstract here

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List of Symbols

Symbol	Description	Unit
\mathbf{A}	vector potential	V s m^{-1}
A	area	cm^2
A^*	Richardson's constant	$\text{A s}^{-1} \text{K}^2$
B	magnetic field	T
C	capacitance	F
E	electric field	V m^{-1}
E	energy	eV (J)
E_{F}	Fermi energy	eV
E_g	bandgap energy	eV
$\hat{\mathbf{H}}$	Hamiltonian	eV (joule)
I	current	A
I_{ds}	drain current	A
L	length	μm
L	channel length	μm
m	mass	kg
m^*	effective mass	kg
n	carrier density	cm^{-2}
n	charge carrier density	C cm^{-2}
$\hat{\mathbf{p}}$	momentum operator	kg m s^{-1}
R	resistance	$\text{k}\Omega \mu\text{m}$ (Ω)
R_c	contact resistance	$\text{k}\Omega \mu\text{m}$
R_H	Hall coefficient	$\text{m}^3 \text{C}^{-1}$
$\hat{\mathbf{s}}$	spin operator	\hbar (Js)

T	temperature	K
V	voltage	V
V_{bg}	backgate voltage	V
V_{ds}	drain voltage	V
V_{H}	Hall voltage	V
w	channel width	μm
μ	mobility	$\text{cm}^2 \text{V}^{-1} \text{s}^{-1}$
μ_{B}	magnetic moment	eV T^{-1}
μ_e	electron mobility	$\text{cm}^2 \text{V}^{-1} \text{s}^{-1}$
μ_{FE}	field-effect mobility	$\text{cm}^2 \text{V}^{-1} \text{s}^{-1}$
μ_{H}	Hall mobility	$\text{cm}^2 \text{V}^{-1} \text{s}^{-1}$
μ_p	hole mobility	$\text{cm}^2 \text{V}^{-1} \text{s}^{-1}$
ρ	resistivity	Ωcm
ρ_{xx}	longitudinal resistivity	Ω
ρ_{xy}	transverse resistivity	Ω
σ	conductivity	μS
σ_{xx}	longitudinal conductivity	μS
σ_{xy}	transverse conductivity	μS
τ	scattering time	s
τ_{q}	quantum scattering time	s
Φ_{B}	barrier height	eV
$\Phi_{\text{B}n}$	electron barrier height	eV
$\Phi_{\text{B}p}$	hole barrier height	eV
Φ_{M}	metal work function	eV
Φ_{S}	semiconductor work function	eV
χ	electron affinity	eV
χ_{S}	semiconductor electron affinity	eV
ω_c	cyclotron frequency	Hz

List of Physical Constants

Symbol	Quantity	Value
μ_B	Bohr magneton	$9.274\,009 \times 10^{-24} \text{ J T}^{-1}$ $5.788\,381 \times 10^{-5} \text{ eV T}^{-1}$ $e\hbar/2m_e$ (atomic units)
k_B	Boltzmann's constant	$1.380\,66 \times 10^{-23} \text{ J K}^{-1}$
ϵ_0	Dielectric constant	$8.854\,18 \times 10^{-12} \text{ A}^2 \text{ s}^4 \text{ kg}^{-1} \text{ m}^{-3}$ $8.617\,34 \times 10^{-5} \text{ eV K}^{-1}$
e	Elementary charge	$1.602\,18 \times 10^{-19} \text{ C}$
m_e	Electron mass	$9.109\,383 \times 10^{-31} \text{ kg}$
eV	Electron volt	$1.602\,18 \times 10^{-19} \text{ J}$
c	Speed of light	$2.997\,92 \times 10^8 \text{ m s}^{-1}$
h	Planck's constant	$6.626\,07 \times 10^{-34} \text{ J s}$
μ_0	Permeability in vacuum	$1.256\,63 \times 10^{-6} \text{ m kg s}^{-2} \text{ A}^{-2}$ $4\pi \times 10^{-7} \text{ m kg s}^{-2} \text{ A}^{-2}$
\hbar	Reduced Planck's constant	$1.054\,57 \times 10^{-34} \text{ J s } (h/2\pi)$
$k_B T$	Thermal energy	$0.025\,86 \text{ eV } (T = 27^\circ\text{C})$ $0.025\,26 \text{ eV } (T = 20^\circ\text{C})$
R_{K-90}	von Klitzing constant	$25\,812.807\,455\,55 \, \Omega$

Source: CODATA Recommended Values of the Fundamental Physics Constants: 2014, Mohr *et al.*¹

Conversion Factors

Conversion Factors	
1 Å	= 0.1 nm
	= 10^{-4} μm
	= 10^{-8} cm
	= 10^{-10} m
1 μm	= 10×10^4 Å
	= 10^3 nm
	= 10^{-4} cm
	= 10^{-6} m
1 eV	= 1.60218×10^{-19} J

Powers of Ten

10^{24}	yotta	Y
10^{21}	zetta	Z
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^9	giga	G
10^6	mega	M
10^3	kilo	K
10^2	hecto	h
10^1	deka	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a
10^{-21}	zepto	z
10^{-24}	yocto	y

Acronyms

SB Schottky barrier

Chapter 1

Chapter Title

1.1 Section Title

Contents here with Schottky barrier (SB). i

Chapter 2

Chapter Title

2.1 Section Title

Chapter 3

Chapter Title

3.1 Section Title

Chapter 4

Chapter Title

4.1 Section Title

References

- [1] PJ Mohr, DB Newell, and BN Taylor. Codata recommended values of the fundamental constants 2014,(2015). *arXiv preprint arXiv:1507.07956*, 2015.